THE ASSESSMENT OF THE ATMOSPHERIC POLLUTION BY ACCUMULATION OF THE HEAVY METALS IN CENTRAL AND PERIPHERAL PARTS OF *Xanthoria parietina* (L.) Th. Fr., ROMANIA

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Abstract. This study is focused on heavy metals accumulation by *Xanthoria parietina* (L.) Th. Fr., identified on trees as components of shelterbelts. The fieldwork was performed in three counties – Călăraşi, Vaslui and Dolj – during June-December 2015. A single shelterbelt was investigated in Vaslui and Dolj, while four shelterbelts were investigated in Călăraşi. Thus, six sampling units were selected within each of the shelterbelts, with an area of 9 m^2. In the laboratory, the collected lichen thalli were shifted into two thalline components, i.e. the central and peripheral parts of the thalli. The heavy metals accumulation was analysed both in the central and the peripheral parts of the thalli. The results have indicated that heavy metals were accumulated to a higher extent in the central part of thalli than in peripheral parts. The main source of pollution with heavy metals in the studied sites is car traffic.

Keywords: shelterbelts, *Xanthoria parietina*, pollution, heavy metals, Romania.

Rezumat. Evaluarea poluării atmosferice prin acumularea metalelor grele în părţile centrale şi periferice ale speciei *Xanthoria parietina* (L.) Th. Fr., România. Acest studiu se bazează pe acumularea metalelor grele de către *Xanthoria parietina* (L.) Th. Fr., identificată pe arbori din cadrul perdelelor forestiere. Cercetările în teren s-au realizat în trei judeţe Călăraşi, Vaslui şi Dolj în perioada Iunie-Decembrie 2015. În judeţele Vaslui şi Dolj au fost investigate câte o peredea forestieră în timp ce în Judeţul Călăraşi au fost cercetate patru perdele forestiere. În cadrul fiecărei perdele forestiere au fost selectate câte şase unităţi de probă cu o dimensiune de 9 m^2. În laborator, talurile de licheni colectate au fost separate în două componente taline şi anume: părţile centrale şi periferice ale talurilor. Acumularea metalelor grele a fost analizată atât în părţile centrale cât şi periferice ale talurilor. Rezultatele au indicat că metalele grele au fost acumulate în mare măsură în partea centrală a talurilor în comparaţie cu cea periferică. În siturile studiate principala sursă de poluare cu metale grele este traficul rutier.

Cuvinte cheie: perdele forestiere, *Xanthoria parietina*, poluare, metale grele, România.

INTRODUCTION

The first data on environmental pollution assessed by heavy metals accumulation in lichens were published in 1839 (FARKAS et al., 2001). In the context of this work, the role of forest shelterbelts in the mitigation of the air pollution caused by car traffic and other anthropogenic sources is well known in Romania (GAVRILESCU & BOLEA, 2014). The role of lichens as biomonitors and bioindicators in the assessment of atmospheric quality is also well known; these organisms are efficient acumulators of chemical elements (IANOVICI et al., 2009). Lichens are useful indicators of high contamination with heavy metals caused by anthropogenic sources such as: steel works and power plants (STATE et al., 2010; 2012). In this respect, it has been seen that lichens accumulate higher concentrations of heavy metals as Fe, Pb and Cu (KÉKEDY-NAGY & BARTÓK, 2008).

Biomonitoring by using lichens is necessary for the progressive assessment of the environmental quality. Assessment of the lichens species' presence in a spatial gradient reveals a delimitation of the polluted areas (LARSEN et al., 2007). Thus, ''epiphytic lichens proved to be very effective as an early warning system to detect signs of a changing environment at forest ecosystems'' (LOPPI & PIRINTSOS, 2003).

Although policies have a significant impact on the environment health, the habitats of lichens are still affected by pollution (GIORDANI, 2007). The improvement of atmospheric quality is highlighted by the recolonisation of the lichen species in regions with a strong impact of pollution (FARKAS et al., 2001; FRIEDEL & MÜLLER, 2004).

The aim of this study is to highlight the quantity of heavy metals accumulated in the central and peripheral parts of *Xanthoria parietina* (L.) Th. Fr. The main objective of the paper is based on the identification of differences between heavy metals accumulation in the central and peripheral parts of lichen thalli. Thus, higher concentrations are moreexpected in the central parts of lichen thalli (older parts) than in the peripheral parts (juvenile parts).

MATERIALS AND METHODS

A total of six shelterbelts were investigated in the studied area (Table 1). Thus, four of them were investigated in Călăraşi County, one in Vaslui County and one in Dolj County (Fig. 1). Within each shelterbelt, six sampling units were selected, of which 3 were situated near the roadway and the other far away from the roadway, but parallel to the first ones (Table 1). A reasonable distance was kept between sampling units. Each sampling unit had an area represented by 3 m × 3 m. *Xanthoria parietina* was collected on the available trees from each sampling units at a high of 1 m above the ground.

The geographical attributes (counties, localities situated close to all investigated forest formations, altitude, GPS coordinates), metrical characteristics (the length and width of the all of them), car traffic, category of roads (Table

2), floristical composition, as well as the presence of plastic waste near each forest shelterbelts (Table 1; Table 3) were mentioned at the level of the each shelterbelt. The intensity of car traffic was assessed by counting the number of cars for ten minutes (the number of cars passing by) and the driving time (DONICA, 2007).

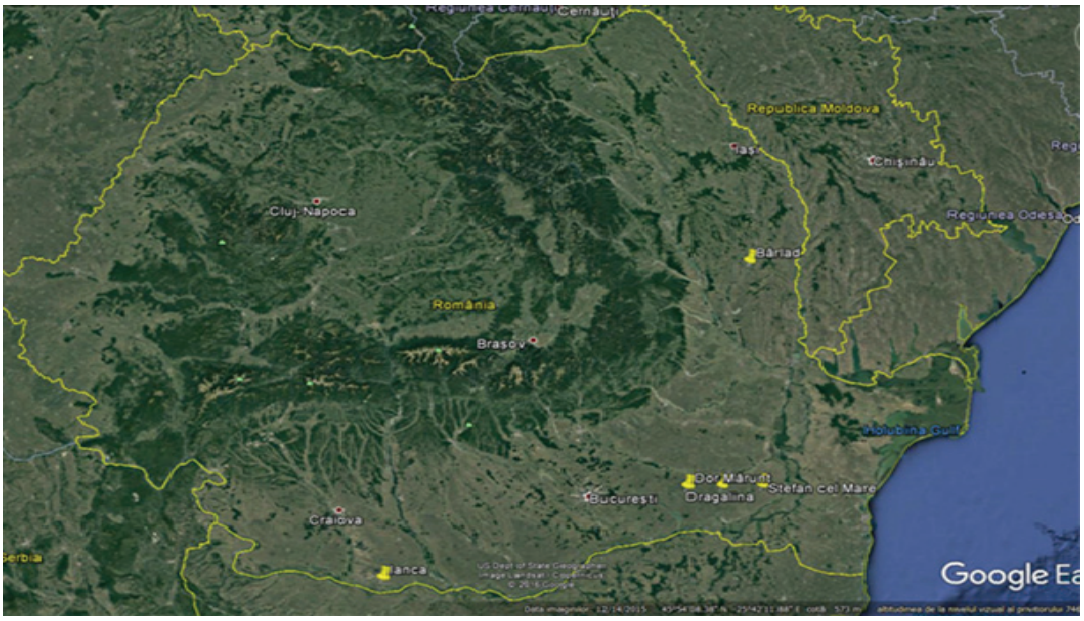

Figure 1. The geographical position of the investigated shelterbelts (https://www.google.ro/maps).

Table 1. The description of the sampling information within the studied area.

County	Locality	Number of the sampling units	Host trees of the lichen species
Călărași/1	Near Dor Mărunt	6	*Robinia pseudacacia* L.
Călărași/2	Near Dragalina	6	*Robinia pseudacacia* L.
Călărași/3	Near Dragalina	6	*Robinia pseudacacia* L.
Călărași/4	Near Ștefan cel Mare	6	*Robinia pseudacacia* L.
Vaslui	Near Bârlad	6	*Gleditsia triacanthos* L., *Robinia pseudacacia* L., *Acer negundo* L., *Juglans regia* L.
Dolj	Near Ianca	6	*Robinia pseudacacia* L.

Table 2. Geographical, metrical, traffic car and roadway characteristics for the investigated shelterbelts.

County	Locality	Altitude (m)	GPS coordinates	Metrical characteristics (km)	Car intensity	Driving time	Road category
Călărași/1	Near Dor Mărunt	48	44.43454°N 26.97512°E	L ~ 4, l ~ 0.025	-	-	NR 3A
Călărași/2	Near Dragalina	49	44.43195°N 27.11026°E	L ~ 3, l ~ 0.050	-	-	NR 3A
Călărași/3	Near Dragalina	38	44.42448°N 27.48567°E	L ~ 7, l ~ 0.025	-	-	NR 3A
Călărași/4	Near Ștefan cel Mare	46	44.42148°N 27.65607°E	L ~ 1.5, l ~ 0.006	-	-	NR 3A
Vaslui	Near Bârlad	71	46.19706°N 27.64443°E	L ~ 0.40, l ~ 0.035	57	10^{17} - 10^{27}	NR 24
Dolj	Near Ianca	38	43.78551°N 24.13971°E	L ~ 0.40, l ~ 0.035	-	-	NR 54A

Legend: L – length, l – width, NR –National Road

In the studied area *X. parietina* has not been rather abundant to be collected or in some cases has been absent on investigated trees. Lichen thalii were identified and collected on black locust only near Dragalina (Călărași County) within the third station, because *X. parietina* was somehow abundant on available trees (Table 3). The collected lichen samples were transported in laboratory and were cleaned using tweezers. The sample was not washed to avoid heavy metals loss. The third station from Călărași County is represented by **one** sample of thalli split up into two thalline components: central parts and peripheral ones. The concentration of the following heavy metals was measured: Pb, Cd, Ni, As, Hg, Al, Cs, Cr, Zn, Co, Cu, Fe and Mn (Table 4) by Energy Dispersive X-ray Fluorescence (EDXRF). The map was created using https://www.google.ro/maps.

RESULTS AND DISCUSSIONS

Of the all investigated shelterbelts *X. parietina* for heavy metals analysis was only collected in one. Due to the lowest abundance of the *X. parietina* (Fig. 2) on the tested trees, only one sample was collected within a shelterbelt situated in the third site from Călăraşi County (Table 3).

Table 3. Field observations on both host trees of the investigated lichen species and studied shelterbelts.

County	Host trees of the lichen species	Observations
Călăraşi/1	*Robinia pseudacacia* -	The cover of the lichen species was higher under a high of 1 m. The cover of *X. parietina* and *Phaeophyscia* sp. was very lower at a high of 1 m above on elms and acacias.
Călăraşi/2	*Robinia pseudacacia*	The trees were not covered with lichens!
Călăraşi/3	*Robinia pseudacacia*	*Xanthoria parietina* has been abundently on *Robinia pseudacacia*
Călăraşi/4	*Robinia pseudacacia*	The cover with *X. parietina* was rather low.
Vaslui	*G. triacanthos, R. pseudacacia, A. negundo, J. regia*	The cover of *X. parietina* and *Phaeophyscia* sp. was very low at a height of 1 m above. Lichen coverage was lower on facing the road. Plastic waste was stored near this forest formation.
Dolj	*Robinia pseudacacia*	The cover with *Physcia adscendens*, *X. parietina* şi *Evernia prunastri* was lower on trees facing the road. Plastic waste was stored near this forest formation.

Figure 2. *Xanthoria parietina* on a corticolous substrata (photo: Vicol Ioana, 01.09.2015, original).

Generally, it was observed that the central parts of lichens have accumulated higher concentrations of heavy metals than younger parts (Table 4).

Table 4. The heavy metal concentrations in collected *Xanthoria parietina* samples.

Heavy metals	Central parts	Peripheral parts
Pb	4,70	2,89
Cd	0*	0*
Ni	2,45	6,53
As	0,91	0,64
Hg	0,30	0,35
Al	674,11	514,51
Cs	0*	0*
Cr	2,47	2,43
Zn	51,56	22,09
Co	0*	0*
Cu	7,64	7,66
Fe	1046,37	893,70
Mn	31,27	32,01

Legend: *under the detection limit

The investigated site was situated near the roadway, therefore the main pollution source with heavy metals in this case is vehicular traffic. Another study revealed that the increase of distance from the roadway is correlated to a decrease of Pb, Cd, Cr and Zn (VICOL, 2014). Also, plastic waste stored near or within shelterbelts (Fig. 3) is another source of heavy metal pollution. In the present study, especially near shelterbelts from Vaslui (near Bârlad) and Dolj (near Ianca) counties, plastic waste was stored, that could represent a synergic source of heavy metals in the atmosphere.

Figure 3. *Xanthoria parietina* on its host trees (black locust) within a shelterbelt situated near Ianca in Dolj County, along NR 54A (photo: Vicol Ioana, 08.12.2015, original).

Car traffic is responsible for the release of heavy metals such as Pb, Cd, Cr, Zn, Mn, Cu into the atmosphere. Thus, by combustion of unleaded petrol and diesel oil, Pb contamination is rather obviously, especially by attrition of tyre wear and brakes. Also, Cd and Zn are found in higher concentrations in the environment (ULUOZLU et al., 2007; ASLAN et al., 2011). Other studies revealed differences between lichen species as regard heavy metal accumulation due to morpho-anatomical and eco-physiological particularities. Thus, *Parmelia sulcata* Taylor with a foliose thalli has accumulated Fe, Mn, Ni and Ti whilst *Evernia prunastri* (L.) Ach. with a fruticose thalli has accumulated Cu in natural areas from southeastern Serbia. In the same study within two polluted localities, both lichen species have accumulated Fe and Zn (Cerje locality) and Ba (Donje Vlase locality) STAMENKOVIĆ et al. (2013).

Otherwise, as regard the accumulation of heavy metals in cormophytes, in a study performed on coniferous vegetation along a roadside in Hamden (Connecticut, United States) a greater concentration of Pb was revealed in older needles than in younger needles. In this study, it was demonstrated that far away from the roadway, the shelterbelt has an important role in the mitigation of pollution (HEICHEL & HANKIN, 1976). Forested areas have a great importance for heavy metal mitigation in the atmosphere. This facts show that forest habitats act as biotic barrier against pollution (STATE et al., 2010). In a study performed in Vallombrosa (Italy), it was found that car traffic represents a risk to the health of forest ecosystems and their associated lichen species, especially by Pb contamination (LOPPI & PIRINTSOS, 2003). *Evernia prunastri* was used to monitor atmospheric pollution in Colle di Val d'Elsa (Italy). It was shown that the used lichen species accumulated Na, Cr, Cu, Fe Pb and V in higher concentrations. In this case, car traffic and a crystal factory are the main anthropic sources of environmental pollution (LOPPI & FRATI, 2006). In Romania, the assessment of environmental pollution with Pb, Cu, and Zn by using lichen species was performed in Zlatna and Baia Mare. Zlatna was revealed to be one of the strongly polluted regions on the world because of anthropogenic activities occurring for a long time (BARTÓK & RUSU, 2004).

CONCLUSIONS

It was observed that central parts of lichen thalli are prone to a higher accumulation of heavy metals than peripheral ones. This capacity to accumulate heavy metals contributes to an improvement of atmospheric quality and, consequently, to the reduction of chemical elements in environment.

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